

## CLAIMS

What is claimed is:

1. A wireless tire pressure sensing system for an aircraft, said system comprising:  
dual resonant circuits mounted to a wheel of the aircraft, one resonant circuit comprising: a first variable capacitance sensor for monitoring the pressure of a tire mounted to said wheel; and a first wire loop of a first predetermined inductance coupled to said first variable capacitance sensor, and the other resonant circuit comprising: a second variable capacitance sensor operative as a reference to said first variable capacitance sensor; and a second wire loop of a second predetermined inductance coupled to said second variable capacitance sensor;  
an interrogating circuit magnetically coupleable to said dual resonant circuits and operative to induce magnetically a variable frequency current in the dual resonant circuits, said one resonant circuit responding to said induced current with an E-field signal at a first resonant frequency commensurate with the capacitance of said first variable capacitance sensor, and said other resonant circuit responding to said induced current with an E-field signal at a second resonant frequency commensurate with the capacitance of said second variable capacitance sensor;  
a receiving circuit E-field coupleable to said dual resonant circuits and operative to receive said E-field signals at said first and second resonant frequencies and to generate first and second signals representative thereof; and  
a processing circuit coupled to said receiving circuit for processing said first and second signals to generate a compensated pressure reading of said tire.
2. The system of claim 1 including a reading unit containing the interrogating circuit, the receiving circuit and the processing circuit, said reading unit including a display coupled to the processing circuit for displaying the compensated pressure reading.
3. The system of claim 1 wherein the interrogating circuit, the receiving circuit and the processing circuit are disposed on a landing gear to which the aircraft wheel is mounted.

4. The system of claim 3 wherein the first and second wire loops are mounted in close proximity to each other on a hubcap of the wheel; and wherein the first and second variable capacitance sensors are disposed in a common enclosure which is mounted to the rim of the wheel, the first and second wire loops being coupled through wire conductors to the first and second variable capacitance sensors, respectively, to form the first and second resonant circuits.
5. The system of claim 4 wherein the common enclosure is pneumatically coupled to a pressure chamber of the tire through a cavity in the wheel rim to enable the first variable capacitance sensor to monitor the tire pressure.
6. The system of claim 5 wherein the common enclosure includes: an opening in a wall thereof, said opening providing an air passageway solely to the first variable capacitance sensor; and a hollow tube coupled to said wall and enclosing said opening in the hollow portion thereof, said hollow tube disposed in the cavity of the wheel rim.
7. The system of claim 4 wherein the common enclosure is vacuum sealed.
8. The system of claim 3 wherein the interrogating circuit comprises: a magnetic interrogator mounted in close proximity to the first and second wire loops of the dual resonant circuits; and an oscillator circuit for driving the magnetic interrogator to generate a variable frequency magnetic field directed toward the first and second wire loops of the resonant circuits.
9. The system of claim 8 wherein the first and second wire loops are mounted in close proximity to each other on a hubcap of the wheel; wherein the magnetic interrogator is mounted on an axle of the wheel in close proximity to the first and second wire loops; and wherein the oscillator circuit is mounted on a strut of the landing gear and coupled to the magnetic interrogator through wire conductors.

10. The system of claim 3 wherein the receiving circuit comprises: a third wire loop mounted in close proximity to the first and second wire loops of the dual resonant circuits and operative to receive E-field signals solely within an E-field null of the magnetic coupling of the interrogator circuit, said E-field signals including E-fields at the first and second resonant frequencies; and a sensing circuit coupled to the third wire loop for converting the received E-field signals at the first and second resonant frequencies into the first and second signals representative thereof.

11. The system of claim 10 wherein the first and second wire loops are mounted in close proximity to each other on a hubcap of the wheel; wherein the third wire loop is mounted on an axle of the wheel in close proximity to the first and second wire loops; wherein the sensing circuit and processing circuit are mounted on a strut of the landing gear; and wherein the sensing circuit is coupled to the third wire loop through wire conductors.

12. The system of claim 1 wherein the first and second variable capacitance sensors comprise substantially identical integrated circuit structures.

13. The system of claim 1 wherein the first and second variable capacitance sensors comprise micro-electro-mechanical system (MEMS) sensors.

14. The system of claim 1 wherein the first and second wire loops are disposed on temperature stable material.

15. The system of claim 1 wherein the first and second wire loops are disposed on a single layer of temperature stable material.

16. The system of claim 1 wherein at least one of the first and second wire loops is physically trimable.

17. The system of claim 1 wherein the processing circuit includes an indicator for displaying a tire pressure condition.

18. The system of claim 1 wherein the indicator comprises a non-volatile indicator.
19. The system of claim 1 including a phase lock loop circuit coupled to both of the interrogating circuit and receiving circuit for locking on to the first and second resonant frequencies.
20. The system of claim 1 wherein the processing circuit generates the compensated pressure reading as a function of the difference of the first and second resonant frequencies.
21. The system of claim 1 including an aircraft bus; and wherein processing circuit is coupled to the aircraft bus for conducting the compensated pressure reading over the aircraft bus.
22. The system of claim 21 wherein the interrogating and processing circuits receive power from the aircraft bus.
23. A method of wirelessly measuring pressure of a tire of an aircraft; said method comprising the steps of:
  - mounting first and second resonant circuits to a wheel of the aircraft to which the tire is mounted;
  - monitoring tire pressure with said first resonant circuit;
  - using said second resonant circuit as a reference to said first resonant circuit;
  - generating a variable frequency signal;
  - magnetically coupling the variable frequency signal to the first and second resonant circuits;
  - inducing first and second resonant frequencies in the first and second resonant circuits, respectively, by the magnetically coupled variable frequency signal, said first resonant frequency representative of an uncompensated pressure reading and said second resonant frequency signal representative of a compensation reading;
  - E-field coupling the first and second resonant frequencies from the first and second resonant circuits to a receiver circuit; and

generating a compensated pressure reading from the E-field coupled first and second resonant frequencies.

24. The method of claim 23 including the step of phase locking the variable frequency signal to the E-field coupled first and second resonant frequencies.

25. The method of claim 24 including the steps of: sweeping the variable frequency signal over a range of frequencies which include the first and second resonant frequencies; determining the variable frequency signal upon phase lock to each of the E-field coupled first and second resonant frequencies.

26. The method of claim 24 including the steps of: sweeping the variable frequency signal over a range of frequencies which include the first and second resonant frequencies; dwelling the frequency sweep for a period of time at phase lock to each of the E-field coupled first and second resonant frequencies; and determining the first and second resonant frequencies during said dwell periods.

27. The method of claim 23 including the step of generating a compensated pressure reading as a function of the difference between the E-field coupled first and second resonant frequencies.

28. The method of claim 23 including the step of conveying the compensated pressure reading over a bus of the aircraft.

29. The method of claim 23 including the step of displaying a tire pressure condition based on the compensated pressure reading on a non-volatile indicator.

30. The method of claim 23 wherein the step of using includes using the second resonant circuit as a temperature compensation reference.

31. A wireless tire pressure and wheel speed sensing system for an aircraft, said system comprising:

a resonant circuit mounted to a wheel of the aircraft for monitoring the pressure of a tire mounted to said wheel, said resonant circuit comprising a wire loop of a predetermined inductance;

an interrogating circuit magnetically coupleable to said resonant circuit and operative to induce magnetically a variable frequency current in the wire loop of said resonant circuit, said resonant circuit generating a corresponding variable frequency electric field in response to said induced current, said variable frequency electric field including a resonant frequency commensurate with the pressure of said tire;

a magnetic field altering apparatus for alternating the magnetic coupling between said wire loop and said interrogating circuit to cause a rate of amplitude modulations of said variable frequency electric field commensurate with said wheel speed;

a receiving circuit E-field coupleable to said resonant circuit and operative to receive said amplitude modulated variable frequency electric field of said resonant circuit and to generate a signal representative thereof;

a first processing circuit coupled to said receiving circuit for processing said signal to generate a pressure reading of said tire based on the resonant frequency thereof; and

a second processing circuit coupled to said receiving circuit for processing said signal to generate a wheel speed reading based on the rate of amplitude modulations thereof.

32. The system of claim 31 wherein the magnetic field altering apparatus comprises a plurality of magnetic field gratings disposed on the wheel about the perimeter of the wire loop at predetermined intervals for rotation therewith, said gratings acting as shutters to the magnetic coupling at the predetermined intervals during wheel rotation.

33. The system of claim 32 wherein the gratings are electrically grounded to prevent the radiation of a magnetic field therefrom.

34. The system of claim 31 wherein the magnetic field altering apparatus comprises first and second concentrically disposed pluralities of magnetic field gratings, said first plurality of gratings disposed on the wheel about the perimeter of said wire loop at predetermined

intervals for rotation therewith, and said second plurality of gratings mounted stationary with respect to said first plurality of gratings, said first and second pluralities of gratings acting as shutters to the magnetic coupling at the predetermined intervals during wheel rotation.

35. The system of claim 31 wherein the magnetic field altering apparatus comprises a plurality of elements of ferro-magnetic material disposed on the wheel about the perimeter of said wire loop at predetermined intervals for rotation therewith.

36. The system of claim 31 wherein the magnetic field altering apparatus comprises a plurality of permanent magnets disposed on the wheel about the perimeter of said wire loop at predetermined intervals for rotation therewith.

37. The system of claim 31 including an aircraft bus; and wherein the first and second processing circuits are coupled to said aircraft bus for conducting the tire pressure reading and wheel speed reading over the aircraft bus.

38. A wireless tire pressure sensing system for an aircraft, said system comprising:  
a resonant circuit mounted to a wheel of the aircraft, said resonant circuit comprising:  
a variable capacitance sensor for monitoring the pressure of a tire mounted to said wheel;  
and a wire loop of a predetermined inductance coupled to said variable capacitance sensor;  
an interrogating circuit magnetically coupleable to said resonant circuit and operative to induce magnetically a variable frequency current in the resonant circuit, said resonant circuit responding to said induced current with an E-field signal at a resonant frequency commensurate with the capacitance of said variable capacitance sensor;  
a receiving circuit E-field coupleable to said resonant circuit and operative to receive said E-field signal at said resonant frequency and to generate a signal representative thereof;  
and  
a processing circuit coupled to said receiving circuit for processing said signal to generate a pressure reading of said tire.

39. The system of claim 38 wherein the receiving circuit comprises: a second wire loop mounted in close proximity to the wire loop of the resonant circuit and operative to receive E-field signals solely within an E-field null of the magnetic coupling of the interrogator circuit, said E-field signals including E-fields at the resonant frequency; and a sensing circuit coupled to the second wire loop for converting the received E-field signal at the resonant frequency into the signal representative thereof.

40. The system of claim 39 wherein the wire loop of the resonant circuit is mounted on a hubcap of the wheel; wherein the second wire loop is mounted on an axle of the wheel in close proximity to the wire loop of the resonant circuit; wherein the sensing circuit and processing circuit are mounted on a strut of the landing gear; and wherein the sensing circuit is coupled to the second wire loop through wire conductors.

41. A method of wirelessly measuring pressure of a tire of an aircraft; said method comprising the steps of:  
    mounting a resonant circuit to a wheel of the aircraft to which the tire is mounted;  
    monitoring tire pressure with said resonant circuit;  
    generating a variable frequency signal;  
    magnetically coupling the variable frequency signal to the resonant circuit;  
    inducing a resonant frequency in the resonant circuit by the magnetically coupled variable frequency signal, said resonant frequency representative of a pressure reading;  
    E-field coupling the resonant frequency from the resonant circuit to a receiver circuit;  
and  
    generating a pressure reading from the E-field coupled resonant frequency.

42. The method of claim 41 including the step of phase locking the variable frequency signal to the E-field coupled resonant frequency.

43. The method of claim 42 including the steps of: sweeping the variable frequency signal over a range of frequencies which include the resonant frequency; determining the variable frequency signal upon phase lock to the E-field coupled resonant frequency.



44. The method of claim 42 including the steps of: sweeping the variable frequency signal over a range of frequencies which include the resonant frequency; dwelling the frequency sweep for a period of time at phase lock to the E-field coupled resonant frequency; and determining the resonant frequency during said dwell period.

45. The method of claim 41 wherein the step of E-field coupling includes the step of E-field coupling solely within the E-field null of the magnetic coupling to the resonant circuit.

46. The method of claim 41 including the step of conveying the pressure reading over a bus of the aircraft.

47. The method of claim 41 including the step of displaying a tire pressure condition based on the pressure reading on a non-volatile indicator.

48. A wireless wheel speed sensing system for an aircraft, said system comprising:  
a wire loop mounted to a wheel of the aircraft and rotating therewith;  
an interrogating circuit magnetically coupleable to said rotating wire loop and operative to induce magnetically a current signal in said rotating wire loop, said rotating wire loop generating a corresponding electric field in response to said induced current;  
a magnetic field altering apparatus for alternating the magnetic coupling between said wire loop and said interrogating circuit to cause a rate of amplitude modulations of said electric field commensurate with said wheel speed; and  
a receiving circuit statically mounted with respect to the rotating wheel, said receiving circuit operative to receive said amplitude modulated electric field and to generate a signal representative of wheel speed.

49. The system of claim 48 wherein the magnetic field altering apparatus comprises a plurality of magnetic shield gratings disposed about the perimeter of the wire loop at predetermined intervals and insulated therefrom, said magnetic shield gratings acting as shutters to the magnetic coupling at the predetermined intervals during wheel rotation.

50. The system of claim 49 wherein the magnetic shield gratings are electrically grounded to prevent the radiation of a magnetic field therefrom.

51. The system of claim 48 including a support layer mounted to the rotating wheel; wherein the wire loop is disposed at the support layer; and wherein the altering apparatus includes a plurality of magnetic shield gratings disposed on a first side of the layer about the perimeter of the wire loop at predetermined intervals, each grating attached at one end to the first side of the support layer and cantilevered over the wire loop, said gratings acting as shutters to the magnetic field at the predetermined intervals during wheel rotation.

52. The system of claim 51 wherein the altering apparatus includes a second plurality of magnetic shield gratings disposed on a second side of the layer about the perimeter of the wire loop at predetermined intervals, each grating of the second plurality attached at one end to the second side of the support layer and cantilevered over the wire loop.

53. The system of claim 51 wherein the wire loop is embedded in the support layer.

54. The system of claim 51 wherein the support layer is mounted to a hub of the wheel.

55. The system of claim 51 including a supporting ring for coupling together the unattached ends of the plurality of gratings.

56. The system of claim 51 wherein the receiving circuit comprises a statically mounted wire loop concentric with the rotating wire loop; and wherein the altering apparatus includes a second plurality of magnetic shield gratings disposed at predetermined intervals about a static perimeter concentric with the rotating perimeter of the wire loop.

57. The system of claim 56 wherein the static wire loop and second plurality of magnetic shield gratings are mounted to an axle of the wheel.

58. The system of claim 48 including an aircraft bus; and wherein the receiving circuit is coupled to said aircraft bus for conducting the wheel speed signal over the aircraft bus.

59. The system of claim 48 wherein the altering apparatus includes forming shaped extensions from the periphery of the wire loop at predetermined intervals about the periphery, said shaped wire loop extensions causing a rate of amplitude modulations of the electric field commensurate with the wheel speed.

60. The system of claim 59 wherein the wire loop is shaped in the form of a multi-pointed star with said star apexes at the predetermined intervals about the periphery.

61. The system of claim 59 including a support layer mounted to the rotating wheel; wherein the wire loop is disposed at the support layer.

62. The system of claim 48 including a support layer mounted to the rotating wheel; wherein the wire loop is disposed at the support layer; and wherein the altering apparatus includes a plurality of elements of ferro-magnetic material disposed on a first side of the layer about the perimeter of the wire loop at predetermined intervals, said elements acting to distort the magnetic field at the predetermined intervals during wheel rotation.